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PLUGS FOR CEMENTING WELLS, PARTICULARLY OIL WELL BORES AND THE LIKE,
SET OF PLUGS FOR EXECUTING THE CEMENTING OPERATION, AND
EQUIPMENT FOR THE IMPLEMENTATION THEREOF

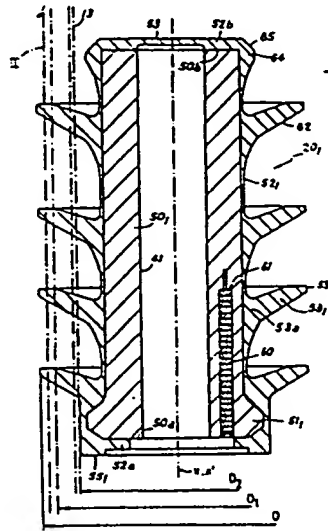
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[Abstract]

- Well bore equipment.
- The plug comprises:
 - a core (50) of resistant material, with a circular transverse cross section,
 - an elastomeric coating (52) on at least the peripheral surface of the core,
 - and peripheral annular blades (53) that are elastically deformable, forming an integral part of the coating from which they extend, stepped according to an axial spacing at least essentially equal to their radial extent, and each defining an exterior [diameter] (D) between 103% and 120% of the inside diameter (D_i) of the pipe (II) to be cemented.

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- Application to cementing plugs.



The present invention concerns equipment for oil well bores and the like, and more specifically it concerns heads adapted to the well casing so as to permit execution, after or during the drilling of well bores, of well bore cementing operations.

These operations proceed as follows:

First, the casing equipped with its nonreturn valve is lowered into the well bore, which is filled with drilling mud. At that moment the casing is also filled with drilling mud.

The first cementing operating consists of causing the drilling mud to circulate for a certain length of time in order thoroughly to clean the annular space of any drilling debris that may be found there.

Then, one or more of the lower plugs is launched from the surface and pushed downward by the cement slurry or the cleaning liquids (chemical wash) or by the spacers provided without pressure.

When a certain amount of cement slurry, calculated to provide a certain height in the annular space between the casing and the rock, has been injected, an upper plug is launched by being pushed by the displacement liquid (generally the mud).

The cement slurry is trapped between the lower plugs and the upper plug, whose role it is to prevent the slurry from mixing with the upstream and downstream liquids, and also to scrape the inside of the casing to prevent any deposit being formed on its inner wall.

When the lower plug(s) come into contact with the nonreturn valve, the high pressure generated on the surface tears the membrane on the lower plug or plugs, thereby allowing the cement slurry to flow into the annular space between the casing and the drilled rocky formation.

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The upper plug continues to drop and finally comes into contact with the lower plug or plugs already resting on the upper surface of the one-way sleeve.

Generally, at this point a pressure test of the casing is conducted. The stack-up of plugs should withstand the pressure.

Then the pressure is released, and the nonreturn valve prevents the slurry from returning to the interior of the casing.

If the nonreturn valve does not work properly, sufficient pressure is maintained inside the casing from the surface in order to press the plugs against the shoulder of the one-way sleeve.

This pressure is maintained for as long as it takes the cement slurry to set.

To perform this type of task, the prior state of the art employs heavy, cumbersome material that is difficult to handle and mount on the upper end of the casing, and is moreover, not very reliable in its performance.

The disadvantages of this technique are well known and are set forth in French Patent Application No. 89 00 062, and in European Patent Application No. 89 203 297.0.


The objects of the above-mentioned applications were to remedy the disadvantages of the known technology by designing a new cementing head structure with built-in plugs subject to the constraint of elastic deformation maintained in a container adapted to the inside of upper end of the casing, and from which container successive launching is made possible, whether remotely or otherwise.

This technique provides for the implementation of plugs having in particular deformable peripheral blades, which are capable of being bent back to a minimum outside diameter in order to be able to be held in place under elastic constraint inside the container, and to be able to deploy elastically so as to have an outside diameter that is smaller than the inside diameter of the casing, so as to function as sealing segments and scrapers when in operation.

Experiments have shown that satisfactory results may be obtained by employing structural devices specific to the characteristic of initial elastic prestressing of the plugs inside the container before being launched into the casing.

The present invention concerns structural devices added to plugs, according to the basic principle of the above-mentioned patent applications, which have been chosen to improve the various functions performed by cementing plugs in particular.

The plugs according to the invention are also of great interest in practice, in the ground, since they can be used for all known thicknesses of casing with a given casing diameter, where it is known that for a given outside casing diameter the thickness will naturally affect the inside diameter, which meant that when using conventional plugs it was necessary to have a range of plugs available with different diameters.



To achieve these objectives, the invention envisages a cementing plug for wells, in particular oil well bores and the like, such that it comprises:

- a core of resistant material, generally elongated in shape with a circular transverse cross section,
- an elastomeric coating on at least the peripheral surface of the core,
- and peripheral annular blades that are elastically deformable, forming an integral part of the coating from which they extend, stepped according to an axial spacing at least essentially equal to their radial extent, formed so as to open out from the base or foot of the core to its top or head, and each defining an exterior diameter between 103% and 120% of the inside diameter of the pipe to be cemented, corresponding, for example, to a casing with a diameter of 9 5/8" (24.4 cm) and a "weight" of 32.3 lb/ft (46.22 kg/m).

A further object of the invention is a set of plugs capable of permitting the execution of a cementing operation, such set being characterized by the fact that it comprises:

- at least one so-called lower plug comprising:
 - a core having a hollow core running through it,
 - and an elastomeric coating covering the peripheral surface of the core, as well as the transverse surface of the head so as to close the opening of the hollow core and form a puncturable seal,
- and a so-called upper plug comprising:
 - a solid core or having a hollow core that does not run the length of it,
 - an elastomeric coating covering the peripheral surface of the core, as well as the surface of the base of the core,
 - and a recessed housing provided in the transverse surface of the head to fit a temporary means of assembly and release carried on the suspension rod of a launching mechanism.

Yet another object of the invention is the special cementing equipment for implementing the set of plugs as described above.

Various other characteristics will be evident from the description below, made with reference to the attached drawings that show, by way of non-limiting examples, embodiment modes of the object of the invention.

Figures 1, 2, and 3 are cross sections illustrating the technique using a cementing head with built-in plugs.

Figures 4 and 5 are cross sections showing the structural characteristics of the plugs according to the invention.

Figures 1 to 3 show an embodiment mode of cementing head I comprising body 2 provided, at the bottom, with means 3 for connection to casing II of oil well P or the like. Means

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3 may be a sleeve or threaded collar, of the type normally used for connecting casing II components.

Body 2 is, for example, composed of lower half-body 4, tubular in shape, and upper half-body 5, said half-bodies being joined, with insertion of sealing means 6, by collar 7 or a similar device designed to fasten them together, by flanges 8 and 9, for example, forming part of half-bodies 4 and 5.

Body 2 is provided with connection means 10 to a source of supply of liquids under high pressure, such as mud, chemical washes, and of course liquids capable of providing annular cementing 11 delimited between well P and casing II. Means 10 open into the inner periphery of cavity 12 defined in the inside by body 2 so as to be aligned with the inner section of casing II when head I fits onto it.

Head I contains, within cavity 12, tubular container 13 that is generally cylindrical in shape, open at its lower end and extending coaxially with half-body 4, and having a diameter that is smaller than that of cavity 12 and of casing II. Container 13 constitutes an independent, removable component that is held in position by screws or clamps, preferably between half-bodies 4 and 5. Tubular container 13 is perforated over its entire length, so as to permit passage between the annular interval delimited in cavity 12 by the volume it itself defines.

Container 13 is designed to act as a temporary storage magazine for plugs 20, any number of which may be provided. Container 13 is preferably designed to contain two plugs 20_1 and 20_2 , to be placed resting one on top of the other so as to touch one another and form a column. Plugs 20 are made so that they include an elongated rotating body 21, preferably cylindrical, having on its outer periphery annular blades 22 that are elastically deformable; which gives each plug, when in a state of rest, a diameter D that is greater than diameter D_1 of container 13 and also than diameter D_2 of casing II. Plugs 20_1 and 20_2 are positioned subject to prestressing by the radial elastic deformation of blades 22, which by reaction ensure the stable superposed stacking of plugs 20.

Completing head I is means 30 used to expel successively the different plugs 20_1 and 20_2 from container 13. Means 30 is in the form of an actuator with a single rod or, on the contrary, with multiple work stages. In the latter, preferred case according to the invention as illustrated in the drawings, the number of work stages is directly related to the number of plugs 20 loaded in container 13. In the present case, therefore, actuator 30 is of the telescoping kind with two stages 31_1 and 31_2 , respectively, and double-acting. This type of construction should be considered known to one skilled in the art and its sole representation in Figure 1 makes it possible to dispense with a description.

Actuator 30 has piston rod 32 that is designed to be a means to drive and exert pressure on the column of stacked plugs 20. To this end, rod 32 is connected to upper plug 20_2 by means

33 for assembly and automatic decoupling, which is controlled in release by the fluid supplied to actuator 30. Means 33 are, for example, retractable pins 34 with elastic return, which are placed in housing 35 in upper plug 20₂.

The operation of the above-described cementing head will be described below.

In the position according to Figure 1, plugs 20₁ and 20₂ are loaded in container 13, which is fixed to half-body 4. System 33 provides an axial connection between the column of plugs and piston rod 32, in its position of maximum retraction.

When it is time to launch lower plug 20₁ inside casing II, actuator 30 is supplied so as to drive rod 32 to slide along a limited stroke. The extension of rod 32 pushes upper plug 20₂, which pushes and expels lower plug 20₁ from container 13, after passing through narrow part 15, if such a narrow part exists, which is not obligatory. In the position illustrated in Figure 2, deformable peripheral blades 22 of plug 20₁ open and touch the inner peripheral wall of casing II, where the plug is now centered.

In this position, a launching fluid may be introduced into cavity 14 by connector 10, in order to push plug 20₁ and launch it toward the interior of casing II, which is scraped by means of blades 22.

After the lower plug is launched and the operating phase or sequence is completed as needed, including the possible perforation of seal 40 covering the top part of hollow core 41 in lower plug 20₁, upper plug 20₂ is launched, driven by actuator 30 to cause piston rod 32 to extend to the second limit of its lengthwise stroke. As before, plug 20 is expelled from container 13 and passes through the eventual narrow part 15 to release the constraint on blades 22. At the end of the stroke, system 35 is caused to retract pins 34, thereby permitting the full release of plug 20₂ from rod 32. As before, upper plug 20₂ can then be propelled by a fluid supplied for that purpose through connector 10.

In order that the above described operations may be carried out with optimum efficiency, plugs 20 are made according to the invention as illustrated in Figures 4 and 5, which represent, respectively, plug 20₁, referred to as the lower plug, and plug 20₂, referred to as the upper plug.

According to the invention, plugs 20, whether lower or upper, have a partly shared structure and specific embodiment modes. The shared structure is described below with reference to the same reference numbers, which are, however, given index 1 or 2 depending on whether they belong to one plug or the other in Figures 4 and 5.

Plug 20 according to the invention includes core 50 of any appropriate existing material, such as polyamide, phenolic resin, or the like, or for certain applications, particularly at high temperatures, of aluminum or an aluminum alloy. Core 50 is generally elongated in form and preferably has a circular transverse cross section. Core 50 has a uniform cross section but, when it must be fitted to certain nonreturn valves, at its base it preferably has projecting annular

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molding 51 that is set back slightly from the lower transverse surface or foot 50_a, the plane of which is perpendicular to axis x-x of core 50. Molding 51 preferably has a radial section in a trapezoidal form whose top and bottom angles are softened by curves having small radii.

Core 50 is provided with coating 52 of a deformable material covering at least the outer peripheral surface. Coating 52 is preferably of an elastomer. A Shore hardness of between 50 and 70 has produced good results.

Coating 52 surrounds annular molding 51 and forms, in integral fashion, elastically deformable peripheral annular blades 53, stepped with a constant axial spacing or not, which is, in any case preferably at least essentially equal to the radial extent of each blade in relation to the outer periphery of coating 52. Peripheral annular blades 53 are provided, for example, three in number, with a roughly constant spacing from base or foot 50_a, each opening outwardly from the base the head or top 50_b. Opening outwardly is understood to mean that each blade opens outward from the base to the outer peripheral edge, according to an orientation that is angled to diverge toward the top 50_b. Each blade 53 is shaped so as to have a progressively decreasing cross section moving from foot 53_a to peripheral edge 53_b, which defines, when in a state of rest, a diameter D that is greater than inner diameter D₁ of casing II, which is greater than inner diameter D₂ of container 13. According to the invention, diameter D is preferably between 103% and 120% of the inside diameter D₁ of the casing, for a diameter of 9 5/8" (24.4 cm) and a "weight" of 32.3 lb/ft (46.22 kg/m) or 91 lb/ft (130 kg/m).

Coating 52 preferably also covers base 50_a, from which it forms lower projecting ridge 55. In the case of the embodiment mode of the plug according to Figure 4, which illustrates lower plug 20₁, lower part 52_a of coating 52 covers the radial extent of base 50_a, not including the section of hollow core 41.

Among the shared structural characteristics, it is also worth mentioning the possible presence in core 50 of magnets 60, which are permanent magnets and positioned, for example, in one or more axially running recessed holes 61. Magnets 60 are designed to permit identification of plug 20₁ or 20₂ through casing II by means of a suitable magnetic field detector, once the plugs are launched to carry out their functions during a cementing phase.

In the case of lower plug 20₁ according to the invention, the specific means provided include, as shown in Figure 4, the existence of a fourth deformable blade 62 formed by coating 52 relatively near top 50_b of core 50. Deformable peripheral blade 62 is preferably identical in structure to blades 53 and is shaped so as to be separated from top 50_b by a distance that is at least approximately equal to its radial extent.

Coating 52 of plug 20₁ has part 52_b covering the entire cross section of top 50_b so as to form in its central section 63 a puncturable seal covering the section over hollow core 41. Seal 63 is designed to perform the function described above in relation to seal 40.

In addition, in the area where it connects with part 52b, coating 52 forms annular ridge 64 that connects to part 52b by so-called centering bevel 65, which engages with ridge 55 on plug 20₂.

In the case of plug 20₂, called the upper plug, according to the invention, core 50 is designed to be solid or possibly with a hollowed out area that does not run through the core. Upper surface 50b, which has no coating, has cavity 66 of the recessed type that defines housing 35 and provides annular groove 67, stepped back from surface 50b, which is designed to engage with retractable pins 34.

In the case of the upper plug, coating 52 forms a fourth peripheral blade 68 that is, however, inflected to include a part 69 in the form of a cylindrical skirt encircling core 50, whose diameter D is equal to that of blades 53. The length of skirt 69 is chosen so that it is limited by a transverse plane running along its peripheral edge and situated below the plane of top 50b.

In addition to the constitution of the plugs as described above, the invention provides for a set of plugs for implementation of the cementing process and involving at least one lower plug 20₁ and one upper plug 20₂, which meet the above characteristics and are designed to be launched successively.

To this end, a further object of the invention is equipment to launch plugs for cementing oil well bores or the like, characterized by the presence of a tubular magazine, as described with reference to Figures 1 to 3, and by the internal loading such a magazine provides. Such loading consists of either a single plug 20₂, or a set of plugs comprising at least one lower plug 20₁ and one upper plug 20₂. In that case, the plugs being loaded subject to prestressing by elastic deformation are placed end to end.

The invention is not limited to the examples described and represented; various modifications are permitted without exceeding the scope thereof.

Claims

1. Plug for cementing wells, in particular oil well bores and the like, characterized in that it comprises:

- a core (50) of resistant material, elongate in shape with a circular cross section,
- an elastomeric coating (52) on at least the peripheral surface of the core,
- and peripheral annular blades (53) that are elastically deformable, forming an integral part of the coating from which they extend, stepped according to an axial spacing at least essentially equal to their radial extent, shaped so as to open out from the base or foot of the core to its top or head, and each defining an exterior diameter (D) between 103% and 120% of the inside diameter (D_i) of the pipe (II) to be cemented.



2. Plug according to Claim 1, characterized in that the elastomeric coating (52) has a Shore hardness of between 50 and 70.

3. Plug according to Claim 1, characterized in that the base of the core (50) has projecting peripheral annular molding (51) surrounded by coating (52) that forms a lower roll (55) projecting from the corresponding transverse surface of the core.

4. Plug according to Claim 1, 2, or 3, characterized in that the coating (52) at least partially covers the transverse surface on the base of the core.

5. Plug according to Claim 1, characterized in that each peripheral blade (53) has a decreasing thickness, in radial section, from its foot (53a) to its peripheral edge (53b).

6. Plug according to Claim 1, characterized in that it has three peripheral blades (53) positioned according to a constant axial spacing from the base, and a fourth blade (62) or (68) that is stepped back from the transverse surface of the head of the core.

7. Plug according to Claim 1 or 6, characterized in that the peripheral blade (68) located near the surface (50b) of the core is inflected to be cylindrical in form (69).

8. Plug according to Claim 1, characterized in that the core has magnets (60) housed in at least one recessed axial hollow (61).

9. Set of plugs for cementing wells, in particular oil well bores and the like, characterized in that it comprises:

- at least one so-called lower plug (20₁) according to one of Claims 1 to 8, and comprising:

- a core (50) having a hollow core (41) running through it,
- and an elastomeric coating (52) covering the peripheral surface of the core, as well as the transverse surface of the head (50b) so as to close the opening of the hollow core and form a puncturable seal (63),

- and a so-called upper plug (20₂) according to one of Claims 1 to 8, and comprising:

- a solid core (50) or having a hollow core that does not run the length of it,
- an elastomeric coating (52) covering the peripheral surface of the core, as well as the transverse surface of the base (50a) of the core,
- and a recessed housing (66) provided in the transverse surface of the head (50b) to fit a means (35) for temporary assembly and release carried on the suspension rod (32) of a launching mechanism (30).

10. Set of plugs according to Claim 9, characterized in that:

- the so-called lower plug (20₁) has a coating (52) that forms a peripheral ridge (64) that connects to the transverse surface of the head (50b) by an annular centering bevel (65),

- the so-called upper plug (20₂) has a ridge (55) formed by the coating (52) which projects from the transverse surface of the base (50a) and is provided to engage with the bevel (65).

11. Set of plugs according to Claim 9, characterized in that the upper plug (20₂) includes a cylindrical, axially recessed housing (66) having an annular groove (67) stepped back from the transverse surface of the head (50b).

12. Plug launching equipment for cementing wells, in particular oil well bores and the like, of the type comprising a body (2) that fits on the upper end of a casing (II) placed in the well (P), characterized in that it comprises:

- tubular magazine (13) open at its lower end, extending downward from the body and having a diameter (D₂) that is smaller than diameter (D₁) of the casing in which it extends at least partially,

- at least one plug or preferably a set of plugs (20) according to one of Claims 10 to 13, mounted one on top of the other with prestressing by elastic deformation in the magazine, and chosen so that when each is at rest the peripheral blades (53) have a diameter (D) that is greater than the inner diameter (D₁) of the casing.

13. Equipment according to Claim 12, characterized in that the magazine has a narrow part (15) of the cross section of its passageway near its open bottom end.

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